

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- HARDWARE****NUMBER: M0-AG1-M18 -X****SUBSYSTEM NAME:** REMOTELY OPERATED FLUID UMBILICAL (ROFU)**REVISION:** 01/23/03**PART DATA**

<b>PART NAME VENDOR NAME</b>	<b>PART NUMBER VENDOR NUMBER</b>
: ROFU	V847-544100-001
: GEAR CAM, ODM LIMIT SWITCH ASSEMBLY (ARM DRIVE)	V751-544252

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

THE CAM GEAR IS A MULTI-FUNCTION DETAIL PART OF THE ARM DRIVE MECHANISM FOR THE ROFU SYSTEM. THE ELEMENT IS MACHINED FROM INCONEL BAR STOCK.

**REFERENCE DESIGNATORS:** N/A**QUANTITY OF LIKE ITEMS:** 1  
ONE PER ROFU ASSEMBLY**FUNCTION:**

THE MULTI-FUNCTIONAL CAM GEAR PROVIDES THE INTERMEDIATE COUPLING BETWEEN THE OUTPUT OF THE ACTUATOR AND THE INPUT CRANK OF THE LINKAGE THAT DRIVES THE UMBILICAL ARM. THE CAM GEAR HOUSES THE BALL LOCK MECHANISM THAT CAN DECOUPLE THE ACTUATOR FROM OTHER PARTS OF THE DRIVE SYSTEM TO ALLOW MANUAL OPERATION OF THE MECHANISM. THE CAM SURFACES ADJACENT TO THE GEAR ARE THE MECHANICAL INTERFACE FOR THE SWITCH MODULES THAT PROVIDE POSITION FEEDBACK AND MOTOR CUT-OFF SIGNAL FOR THE STOW, MATE, AND RELAX POSITIONS. THE CAM GEAR ALSO INCLUDES THE MECHANICAL STOPS, WHICH LIMIT THE TRAVEL OF THE MECHANISM IN THE EVENT OF LIMIT SWITCH FAILURE OR MANUAL OPERATION. IN ADDITION, THE CAM GEAR IS AN INTEGRAL PART OF THE GEAR TRAIN FOR THE MANUAL/EVA DRIVE INTERFACE

**FAILURE MODES EFFECTS ANALYSIS FMEA -- FAILURE MODE**

**NUMBER: M0-AG1-M18- 01**

**REVISION#: 01/23/03**

**SUBSYSTEM NAME: REMOTELY OPERATED FLUID UMBILICAL (ROFU)**

**LRU:**

**CRITICALITY OF THIS**

**ITEM NAME: ODM ARM DRIVE LIMIT SWITCH ASSEMBLY**

**FAILURE MODE: 2/2**

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**FAILURE MODE:**

PHYSICAL BINDING/JAMMING

**MISSION PHASE: OO ON-ORBIT**

<b>VEHICLE/PAYLOAD/KIT EFFECTIVITY:</b>	102	COLUMBIA
	103	DISCOVERY
	104	ATLANTIS
	105	ENDEAVOUR

**CAUSE:**

ADVERSE TOLERANCES/WEAR, CONTAMINATION/FOREIGN OBJECT/DEBRIS, LOSS OF LUBRICANT, FAILURE/DEFLECTION OF INTERNAL PART, TEMPERATURE, FATIGUE, VIBRATION.

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO**

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<b>REDUNDANCY SCREEN</b>	<b>A) N/A</b>
	<b>B) N/A</b>
	<b>C) N/A</b>

**PASS/FAIL RATIONALE:**

**A)**

**B)**

**C)**

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

LOSS OF DEPLOY/STOW/RELAX FUNCTIONS.

**(B) INTERFACING SUBSYSTEM(S):**

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PAYLOAD CANNOT BE DEPLOYED DUE TO INABILITY TO STOW THE ROFU ARM IN ORDER TO PROVIDE REQUIRED CLEARANCE PRIOR TO PAYLOAD DEPLOYMENT.  
RETRIEVED PAYLOAD CANNOT BE REMATED FOR ENTRY.

**(C) MISSION:**

LOSS OF MISSION OBJECTIVE.

**(D) CREW, VEHICLE, AND ELEMENT(S):**

NO EFFECT. STRESS ANALYSIS INDICATED THAT THE ROFU SHOWS NO STRUCTURAL FAILURE WITH CONTINGENCY LANDING SINK RATE OF 7.2 FT/SEC IN THE MID-TRAVEL POSITION.

**SUCCESS PATHS REMAINING AFTER FIRST FAILURE: 0**

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**- TIME TO EFFECT-**

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**REACTION TIME:** SECONDS

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

THE LIMIT SWITCH ASSEMBLY IS SEALED TO EXCLUDE CONTAMINATION. DESIGN FACTOR OF SAFETY IS 1.4 X LIMIT LOAD. ALL COMPONENTS SHOW POSITIVE MARGINS BY ANALYSIS. DESIGN PRECLUDES DAMAGE UNDER STALLED CONDITION.

ALL THE MECHANISM MATERIALS HAVE BEEN CHOSEN FOR HIGH STRENGTH/LOW WEAR CHARACTERISTICS. MECHANISM DESIGNED WITH POSITIVE MARGINS OF SAFETY FOR WORST CASE THERMAL CONDITIONS. ALIGNMENT MECHANISM DESIGNED TO ENSURE PROPER CAPTURE ENVELOPE FOR WORST CASE THERMAL CONDITIONS.

**(B) TEST:****QUALIFICATION:**

THE ROFU MECHANISM IS CERTIFIED PER CR 60-44-544100-001-C. SYSTEM

**QUALIFICATION TESTS INCLUDED:**

- \* VISUAL EXAMINATION TO VERIFY CONFORMANCE TO DRAWINGS, IDENTIFICATION MARKINGS, AND CLEANLINESS.
- \* ENVIRONMENTAL TESTS - VIBRATION FOR 600 SEC/AXIS (STOWED). VIBRATION FOR 1400 SEC/AXIS (MATED) BY THE ROFU QUALIFICATION TEST. FIVE THERMAL / VACUUM CYCLES.
- \* OPERATIONAL LIFE TESTS - 500 CYCLES, BY THE ROFU QUALIFICATION TEST, ON ARM AND LATCH MECHANISM.
- \* QUALIFICATION ACCEPTANCE TESTS TO CERTIFY MECHANISM FOR FIVE ACCEPTANCE THERMAL AND FIVE ACCEPTANCE VIBRATION TESTS.
- \* MAXIMUM DISPLACEMENT TESTS TO VERIFY OPERATIONAL ENVELOPE.
- \* LIMIT, LIMIT PLUS LOADS TESTS TO VERIFY STATIC LOADING.

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\* ARM AND LATCH STALL LOAD TESTS.

ACCEPTANCE:

THE LATCH MECHANISMS WERE RIGGED PER CONTROLLED SPECIFICATION ML0308-0187, PLUS:

- \* ACCEPTANCE VIBRATION RANDOM SPECTRUM 3 MIN/AXIS.
- \* FIVE ACCEPTANCE THERMAL CYCLES.

CERTIFICATION BY ANALYSIS/SIMILARITY:

FACTORS INCLUDE: HUMIDITY, FUNGUS, OZONE, SALTSpray, SAND/DUST, ACCELERATION, FACTORS OF SAFETY, HAIL, LIGHTNING, RAIN, SOLAR RADIATION (THERMAL AND NUCLEAR), STORAGE/OPERATING LIFE, METEOROIDS, ACOUSTICS, AND EXPLOSIVE ATMOSPHERE.

GROUND TURNAROUND:

OMRSD - ANY TURNAROUND TEST CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD

**(C) INSPECTION:**

RECEIVING INSPECTION

MATERIAL AND PROCESS CERTIFICATIONS ARE VERIFIED BY INSPECTION. ALL PURCHASED PARTS ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL

INSPECTION VERIFIES CLEANLINESS IS MAINTAINED. INSPECTION VERIFIES CORROSION PROTECTION PER MA0608-301.

ASSEMBLY/INSTALLATION

DIMENSIONS OF DETAIL PARTS VERIFIED BY INSPECTION. FASTENER INSTALLATION IS VERIFIED BY INSPECTION. ASSEMBLY AND RIGGING OF THE ACTUATOR IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

MATERIAL INTEGRITY VERIFIED BY NON DESTRUCTIVE EVALUATION.

CRITICAL PROCESSES

APPLICATION OF LB0140-005 DRY FILM LUBRICANT PER MA0112-302 IS VERIFIED BY INSPECTION. HEAT TREATING IS VERIFIED BY INSPECTION.

TESTING

ACCEPTANCE TESTING OF THE ACTUATOR ASSEMBLY PRIOR TO DELIVERY IS VERIFIED BY INSPECTION PER APPLICABLE PROCEDURE.

HANDLING/PACKAGING

HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED BY INSPECTION.

**(D) FAILURE HISTORY:**

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CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATA BASE.

**(E) OPERATIONAL USE:**

NONE

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**- APPROVALS -**

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S&R ENGINEER.	:A. NGUYEN	:/s/ Anh Nguyen_____
CARGO/INTEG ITM.	:J. CAPALENI	:/s/ Bob Dueease for_____
DESIGN ENGINEERING	:P. HOE	:/s/ Pham Hoe_____
SSM	:L. J. SALVADOR	:/s/ Pham Hoe for_____
NASA/DCE	:B. BROWN	:/s/ B. Brown_____
MOD	:K. SMITH	:/s/ K. Smith_____
SR&QA	:H. MALTBY	:/s/ Harry Maltby_____
USA/SAM	:R. SMITH	:/s/ R. Smith_____
USA CARGO/INTG ELEMENT	:S. KUNKEL	:/s/ S. Kunkel_____
USA ORBITER ELEMENT	:S. LITTLE	:/s/ Suzanne Little_____